§11. Finite β Effects on the Birth Profile and Beam Orbits of the NBI Heating in the LHD[1]

Murakami, S., Nakajima, N., Okamoto, M.

Since the Shafranov shift in finite β changes the configuration largely in heliotron/torsatrons, it is necessary to take this configuration change into account for evaluating the the heating profile and efficiency of NBI heating. In this paper the finite β effects on the birth profile and the beam orbit in the LHD (tangential injection and E_b = 125keV H^0) are investigated using the NBI beam deposition and orbit following codes. The beam depositions and particle orbits are calculated with three dimensional MHD equilibria carefully calculated using the VMEC code.

The toroidal projections of the birth profile in the Boozer coordinates are shown in Fig. 1; (a) $\beta_0 = 0.0\%$ and $n_0 = 1.0 \times 10^{20}$, (b) $\beta_0 = 0.0\%$ and $n_0 = 0.3 \times 10^{20}$, (c) $\beta_0 = 6.0\%$ and $n_0 = 1.0 \times 10^{20}$, and (d) $\beta_0 = 6.0\%$ and $n_0 = 0.3 \times 10^{20}$. By comparing (a) and (c) we can find that the deposition number at the center region of (c) is larger than that of (a). The center region ($r < 0.5$) deposition is increased ~ 25% in the finite β case ($\beta_0 = 6.0\%$). This shows that the plasma shift due to the finite β effects enhances the center deposition in the high density case. On the other hand the center deposition is not increased so much (~ 5%) in the low density case.

We have next studied the orbits of injected particles in the finite β LHD plasma. Figure 2-(a) and (b) show the drift orbits of the particles with two different plasma β values in the co injection case; (a) $\beta_0 = 0.0\%$ and (b) $\beta_0 = 6.0\%$, where the strength of the magnetic field is $B_0 = 4.0$T. Although the significant changes of the magnetic field configuration can be seen in the $\beta_0 = 6.0\%$ case, the similar orbits in both β cases are obtained in the Boozer coordinates. Figure 2-(c) and (d) show the drift orbits of the particles with B_0 = 1.0T; (c) $\beta_0 = 0.0\%$ and (d) $\beta_0 = 6.0\%$. The larger shifts of the drift orbit than that of B = 4.0T case can be seen in the both β cases and the difference of the orbits between the two β cases is also found. The deformation of the drift orbit is larger in the $\beta_0 = 6.0\%$ case.

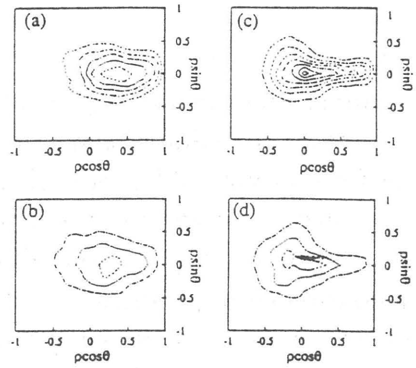

Fig. 1: *Toroidal projections of the NBI birth profile in the Boozer coordinates. (a) $\beta_0 = 0.0\%$ and $n_0 = 1.0 \times 10^{20}\mathrm{m}^{-3}$, and (b) $\beta_0 = 6.0\%$ and $n_0 = 1.0 \times 10^{20}\mathrm{m}^{-3}$.*

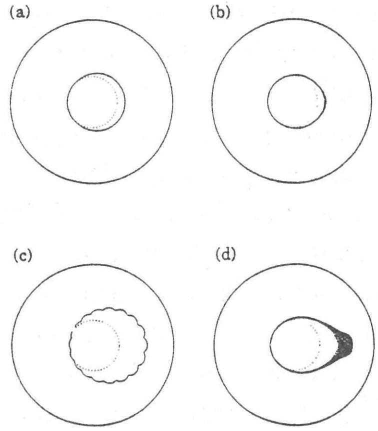

Fig. 2: *Typical orbits of the NBI injected particles in the LHD (tangential injection and E_b = 125keV H^0). (a) $\beta_0 = 0.0\%$ and $B_0 = 4.0$T, (b) $\beta_0 = 6.0\%$ and $B_0 = 4.0$T, (c) $\beta_0 = 0.0\%$ and B_0 = 1.0T, and (d) $\beta_0 = 6.0\%$ and $B_0 = 1.0$T.*

References

1) Murakami, S., et al., Trans. Fusion Technology 27 (1995) 256-259.